(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 534 863 A1**

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: **92402646.1**

(22) Date of filing: **28.09.92**

(51) Int. Cl.^{5}: **D04H 1/54,** D04H 1/56, D04H 13/00

(30) Priority: **30.09.91 US 768831**

(43) Date of publication of application: **31.03.93 Bulletin 93/13**

(84) Designated Contracting States: **AT BE CH DE DK ES FR GB GR IT LI LU NL SE**

(71) Applicant: **FIBERWEB NORTH AMERICA, INC.**
840 Southeast Main Street
Simpsonville, SC 29681 (US)

(72) Inventor: **Allan, John L.**
4 Oak Knob Court
Simpsonville, South Carolina 29681 (US)

Inventor: **Gessner, Scott, L.**
3110 Via Ve Caballo
Olivenhain, California 92024 (US)
Inventor: **Zimmerman, Guy S., Jr.**
104 Aberdare Lane
Greenville, South Carolina 29615 (US)
Inventor: **Austin, Jared A.**
605 Sugar Mill Road
Greer, South Carolina 29650 (US)
Inventor: **Newkirk, David D.**
121 Sunmeadow Road
Greer, South Carolina 29650 (US)

(74) Representative: **Doireau, Marc**
Cabinet Orès 6, avenue de Messine
F-75008 Paris (FR)

(54) **Bonded composite nonwoven web and process.**

(57) The invention is directed to nonwoven fabrics including at least one fibrous web (12) which preferably includes staple or natural fibers, having a bonding layer (22) of thermoplastic material disposed primarily within a substantially discrete cross-sectional portion of the web and below at least one surface of the web. The layer (22) of bonding material comprises a thermally fused thermoplastic web derived from a layer of thermoplastic meltblown fibers. The layer (22) of bonding material can be an elastomeric layer or a non-elastomeric layer thus providing a fabric having elastic or non-elastic properties. The bonding layer adds strength and optionally elastic properties, to the fabric and anchors fibers of the fibrous layer in the fabric. Advantageously, the fabric of the invention is made by hydroentangling a layered web including a first fibrous layer and a layer of meltblown fibers and thermally treating the hydroentangled layered web sufficiently to fuse the thermoplastic meltblown fibers.

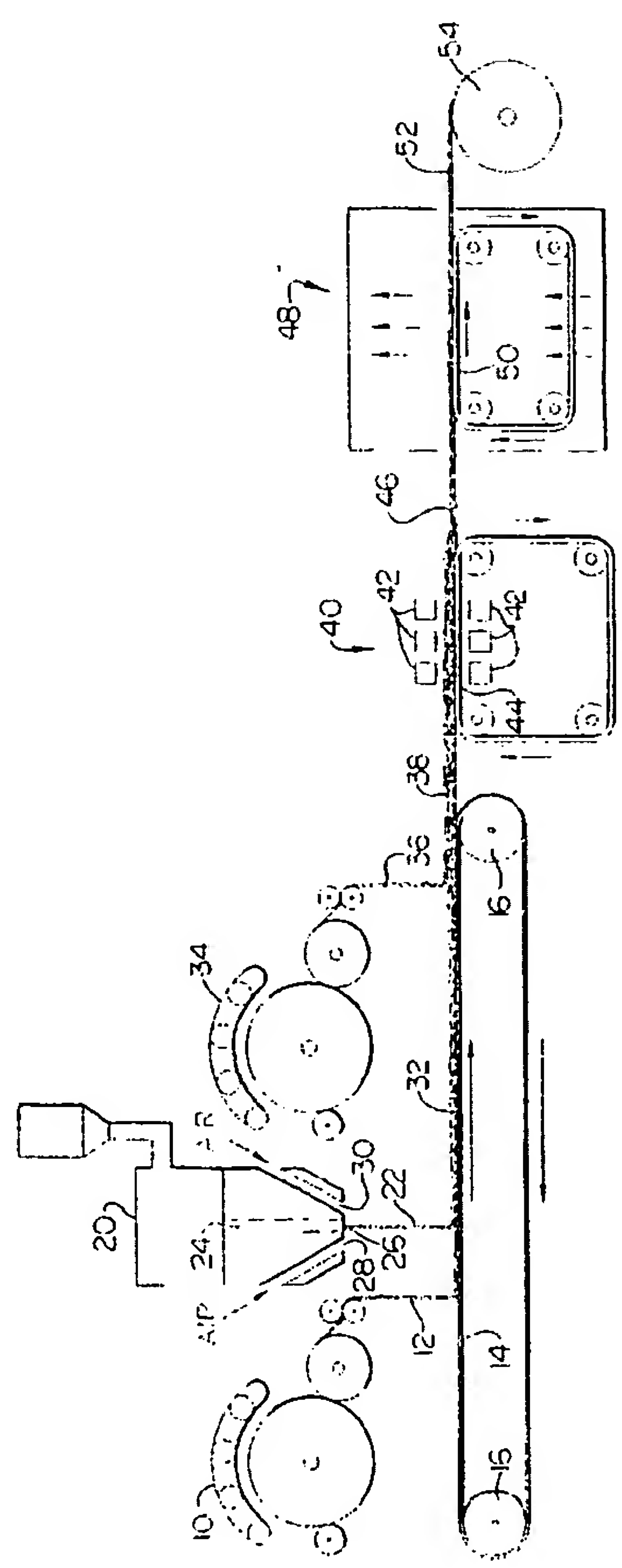

FIG. 1

EP 0 534 863 A1

Field of the Invention

The invention relates to nonwoven fabrics and to a process for producing nonwoven fabrics. More specifically, the invention relates to bonded nonwoven fabrics having improved properties and to processes for producing the fabrics.

Background of the Invention

Nonwoven webs are employed in a variety of products including personal care products such as diapers, disposable wipes, tissues, medical fabrics, clothing, and the like. Nonwoven webs having high strength and a desirable woven cloth-like hand are particularly desirable.

Fabric softness in nonwovens is often achieved by including synthetic staple fibers, wood pulp, or natural fibers such as cotton as one component of the nonwoven web. However, the anchoring of staple fibers in the nonwoven web sufficiently to avoid linting problems and sufficiently to add strength to the fabric can destroy the hand and softness of the fabric. For example, thermal and chemical bonding techniques typically stiffen the fabric resulting in an undesirable fabric texture, softness or hand.

Nonwoven fabrics having elastic properties are particularly desirable for various uses, including use as a component of a personal care fabric, because elastic nonwoven webs can conform to various irregular surfaces such as body surfaces. However, elastic materials typically have a poor hand or feel, and thus elastic nonwovens can suffer from poor fabric aesthetics. The fabric aesthetics can be improved by incorporating staple and/or natural fibers into the elastic nonwoven; however, as discussed above great care must be taken to properly integrate the staple fibers in the elastic nonwoven such that the staple or natural fibers do not cause linting or fuzziness problems.

U.S. Patent 4,775,579 to Hagy, et al. discloses elastic nonwoven fabrics including staple fibers intimately entangled with an elastic web or net. The elastic web can be an elastic meltblown web. The resultant composite web exhibits characteristics similar to those of knit textile cloth while providing desirable elastic extensibility and recovery.

U.S. Patent 4,190,695 to Niederhauser discloses hydraulically needled fabrics including continuous filament textile fibers and staple fibers. The fabric disclosed in this reference is said to alleviate the problem often found in hydroentangled fabrics that staple fibers are not well retained during the lifetime of the fabric. Fiber retention is said to be improved by employing a specific multi-step hydroentangling process and by hydroentangling from both sides of a composite staple/continuous filament fabric.

U.S. Patent 4,542,060 to Yoshida, et al. is directed to a nonwoven fabric having laminate pigs of different types of fibers. The pigs are integrally bound together preferably by hydroentanglement and thereafter the laminate is heated sufficiently to partially soften the fibers of one ply. The heat treatment to soften the fibers of the one ply is conducted under conditions such that deformation of all fibers in the softened ply is avoided to thereby ensure that a portion of the fibers in the ply maintain entanglement with the fibers in the other ply.

U.S. Patent 3,565,745 to Weber, et al. discloses elastic nonwoven fibrous sheets prepared by carding elastic and non-elastic fibers in layers and consolidating the resulting multi-layer laminate as an elastic nonwoven fibrous sheet material. Consolidation can be accomplished by needling and/or by using binders applied either as aqueous dispersions or solutions in organic solvents or by incorporating them into the web as bonding fibers.

U.S. Patent 4,939,016 to Radwanski, et al. and U.S. Patent 4,950,531 to Radwanski, et al. disclose hydraulically entangled webs including meltblown fibers and which are either elastic or non-elastic. The hydraulically entangled laminates can optionally further be treated in a,secondary bonding treatment including thermal bonding, ultrasonic bonding, adhesive bonding, etc. These secondary bonding treatments are said to stiffen the resulting product.

U.S. Patent 4,681,801 discloses laminates comprising a central layer of melt blown organic polymeric fibers and surface layers of reinforcing fibers wherein the reinforcing fibers extend transversely through the melt blown fiber layer and are held in place by bonding to fibers on the opposing face of the central layer. Bicomponent fibers are preferred reinforcing fibers and water jet needling can be used to integrate the plural layers prior to bonding.

Numerous other processes and combinations of processes are used commercially to provide nonwoven webs wherein the fibers and particularly staple fibers, are anchored in the web by various chemical and/or physical means. Despite the widespread use of nonwoven fabrics, many commercially available fabrics still suffer from various shortcomings including insufficient strength, insufficient anchoring of staple fibers, undesirable fuzziness and pilling, and undesirable hand and/or softness. These problems can be particularly acute when one component of the web is a hydrophobic fiber material such as elastomeric hydrophobic fibers which can have an undesirable rubbery feel.

Summary of the Invention

The invention provides nonwoven fabrics of improved strength and/or aesthetics which can be made by simple and straightforward processes. The nonwoven fabrics of the invention can include staple fib-

ers, natural fibers and wood pulp firmly anchored in the fabric so that fiber shedding, fuzziness and pilling problems are minimized or eliminated. The fabrics of the invention can be provided as both nonelastic and elastic fabrics having desirable strength and/or stretch and recovery properties without an undesirable rubbery hand. Moreover, stiffness and roughness qualities associated with nonwoven fabrics including binding agents can be reduced or eliminated in the fabrics of the invention.

The nonwoven fabrics of the invention include at least one fibrous web which preferably includes staple or natural fibers. A bonding layer of thermoplastic material is disposed beneath one surface of the fibrous web and comprises a thermally fused thermoplastic web derived from a layer of thermoplastic meltblown fibers. The thermally fused thermoplastic layer is disposed primarily within a substantially discrete cross-sectional portion of the web; i.e., the thermally fused layer is primarily confined to only a portion of the fabric body in the thickness dimension. The thermally fused layer strengthens the web and anchors the fibers of the fibrous web within the nonwoven fabric.

Nonwoven fabrics according to the invention can be readily manufactured according to another aspect of the invention by intimately hydroentangling a layered web including a first fibrous nonwoven layer, such as a layer of carded staple fibers, with a second layer of meltblown thermoplastic fibers. Following hydroentangling, the laminate is subjected to a bonding treatment for thermal fusion of the meltblown fibers sufficiently that the meltblown fibers are deformed into a substantially non-fibrous structure, e.g. a film-like or film-fiber structure extending throughout the width and length of the meltblown fiber layer. The thermal bonding treatment is conducted under conditions which are insufficient to cause substantial thermal fusion of the fibers in the fibrous layer, thus allowing the fibrous layer to maintain a desirable softness and hand.

Because a thermally fused meltblown thermoplastic layer is used as the bonding layer in the nonwoven fabrics and process of the invention, the thermoplastic bonding layer is primarily maintained in a relatively discrete portion of the fabric cross-section. In general, meltblown thermoplastic webs have a relatively high degree of coherency due to extreme fiber entanglement and/or fiber fusion at cross-over points resulting from the meltblowing process. Typically, in the meltblown web, the fibers are long and entangled sufficiently that it is generally impossible to remove one complete fiber from the mass of fibers or to trace one fiber from beginning to end. Thus, when the fibers of the fibrous layer are entangled with the meltblown web, the meltblown fibrous web retains substantial coherency and integrity and the meltblown fibers undergo minimal, if any, migration in the thickness dimension, i.e. through the cross-section of the fibrous layer.

Due to the lack of migration of the fibers of the meltblown web during hydroentanglement, the subsequent thermal fusion treatment which melts and deforms the meltblown layer, has a minimal or insubstantial aesthetic effect on the remainder of the fibrous layer. This remaining portion of the fibrous layer is primarily or completely devoid of materials of the bonding layer and thus retains substantial aesthetic qualities of softness, hand and the like.

The use of a meltblown thermoplastic fiber web to provide a binder layer in a nonwoven fabric as per this invention, provides a relatively simple and straightforward process for bonding of nonwoven fibers. Meltblown fibers can be, and typically are, extremely fine, typically having a diameter of less than about 1-10 microns. Moreover, the meltblowing process typically does not cause substantial fiber orientation. The combination of extremely fine fiber diameter and the lack of substantial fiber orientation and crystallinity results in fibers which can be more readily melted as compared to thicker oriented fibers such as conventional staple and spunbonded fibers, made from the same polymer.

In one preferred embodiment of the invention, the bonding layer resulting from thermal fusion of the meltblown web is disposed within the cross-sectional interior of the nonwoven fabric and beneath both the top and bottom surfaces of the web. Preferably, these composite fabrics are made by employing at least two fibrous webs in addition to the meltblown web and by locating the webs on both sides of the meltblown web prior to hydroentanglement. The intimately entangled composite web is thermally treated and following thermal treatment, the bonding layer is thus contained within the interior of the fabric thereby resulting in a fabric having desirable softness and hand on both the top and bottom surfaces. Preferably, at least one of the webs is a carded web of staple or natural fibers. The second web can also be a carded web, or can be another nonwoven web such as a spunbonded web. Still further, the second fibrous web can be a woven web, a paper web a net or the like.

The thermoplastic polymer used to form the meltblown nonwoven web can be the same or different as compared to the fibers of the fibrous layer. When the fibrous layer and the meltblown web are made of the same thermoplastic polymer, careful thermal treatment can provide substantial fusion of the meltblown web without thermal fusion of the fibrous layer because the fibers of the meltblown web are less oriented and are of a low thickness and high surface to volume ratio and thus can soften more readily than thicker, more oriented fibers. In addition, the meltblown layer can be of same class of polymer as the fibrous layer but have a lower molecular weight and once softened, the viscosity of the lower molec-

ular weight fibers is lower thus allowing for flowing and bonding. When the meltblown web and the fibrous layer or layers are composed of different thermoplastic polymers, the meltblown web is preferably composed of a thermoplastic polymer having a lower softening point than the fibers in the fibrous layer.

In one particularly preferred embodiment of the invention the meltblown web is formed from an elastomeric thermoplastic material. Even though the fibrous structure of the elastomeric meltblown web is substantially eliminated during the thermal treatment, the resulting composite web still exhibits substantial elastic properties. Because the elastomeric bonding layer is disposed primarily within a substantially discrete cross-sectional region of the composite web and beneath at least one surface of the composite web, the composite web exhibits desirable aesthetic qualities of hand and softness. The thermally fused elastomeric meltblown layer contributes strength and elasticity to the composite web while firmly anchoring the fibers of the fibrous layer into the composite.

Brief Description of the Drawing

In the drawings which form a portion of the original disclosure of the invention:

Figure 1 schematically illustrates one perferred method embodiment of the invention for forming a preferred composite nonwoven fabric of the invention;

Figure 2 is a photomicrograph taken at 40X magnification of one side of a composite fabric according to the invention;

Figure 3 is a cross-sectional photomicrograph at 40X magnification of the nonwoven fabric of Figure 2 and illustrates the thermal fusion of the interior bonding layer;

Figure 4 is a photomicrograph taken at 500X magnification from the top of the composite fabric of Figure 2 and is focused on the interior thermally fused fibers of the composite web;

Figure 5 is a cross-sectional photomicrograph of the composite fabric of Figure 2 taken at a magnification of 200X to further illustrate the thermal fusion of the bonding layer; and

Figures 6 and 7 are cross-sectional views of another preferred composite fabric of the invention and illustrate a higher degree of thermal fusion in the bonding layer as compared to the composite fabrics of Figures 2-5.

Detailed Description of the Invention

In the following detailed description of preferred embodiments of the invention, specific terms are used in describing the invention; however these are used in a descriptive sense only and not for the purpose of limitation. It will be apparent that the invention is susceptible to numerous variations and modifications within its spirit and scope.

Figure 1 schematically illustrates a preferred method and apparatus for producing the composite nonwoven webs of the invention. A carding apparatus 10 forms a first carded layer 12 of manmade or natural fibers. Web 12 is deposited onto forming screen 14 which is driven in the longitudinal direction by rolls 16.

A conventional meltblowing apparatus 20 forms a meltblown fibrous stream 22 which is deposited onto carded web 12. Meltblowing processes and apparatus are known to the skilled artisan and are disclosed, for example, in U.S. Patent 3,849,241 to Buntin, et al. and U.S. 4,048,364 to Harding, et al. The meltblowing process involves extruding a molten polymeric material 24 through fine capillaries 26 into fine filamentary streams. The filamentary streams exit the meltblowing spinneret head where they encounter converging streams of high velocity heated gas, typically air, supplied from nozzles 28 and 30. The converging streams of high velocity heated gas attenuate the polymer streams and break the attenuated streams into meltblown fibers.

Returning to Figure 1, the two-layer carded web/meltblown web structure 32 thus formed, is conveyed by forming screen 14 in the longitudinal direction as indicated in Figure 1. A second carding apparatus 34 deposits a second carded fibrous layer 36 onto the two-layer structure 32 to thereby form a composite structure 38 consisting of a carded web/meltblown web/carded web. The fibers making up carded web 36 can be the same or different as the fibers in carded web 12.

The three-layer composite web 38 is conveyed longitudinally as shown in Figure 1 to a hydroentangling station 40 wherein a plurality of manifolds 42, each including one or more rows of fine orifices, direct high pressure water jets through the composite web 38 to intimately hydroentangle the staple fibers in webs 12 and 36 with the meltblown fibers of web 22.

The hydroentangling station 40 is constructed in a conventional manner as known to the skilled artisan and as described, for example, in U.S. 3,485,706 to Evans, which is hereby incorporated by reference. As known to the skilled artisan, fiber hydroentanglement is accomplished by jetting liquid, typically water, supplied at a pressure of from about 200 psig up to 1800 psig or greater to form fine, essentially columnar, liquid streams. The high pressure liquid streams are directed toward at least one surface of the composite web. The composite web is supported on a foraminous support screen 44 which can have a pattern to form a nonwoven structure with a pattern or with apertures or the screen can be designed and arranged to form a hydraulically entangled composite which is not patterned or apertured. The laminate can be passed through the hydraulic entangling station a

number of times for hydraulic entanglement on one or both sides of the composite web to provide any desired degree of hydroentanglement.

During the hydroentanglement treatment, the staple or natural fibers in carded web layers 12 and 26 are forced into and/or through the meltblown layer 32. Advantageously, the hydroentangling treatment is sufficient to force at least a portion of each of the majority of the fibers through the meltblown layer. The meltblown layer 22, on the other hand, because of its high degree of coherency typically undergoes only a small degree, if any, of movement in the cross-sectional direction within the web. Thus, the meltblown layer 22 remains primarily in a substantially discrete cross-sectional portion in the interior of the composite web.

A condensed, hydraulically entangled composite web 46 exits the hydroentanglement station 40 and is directed into a thermal treatment station 48. Thermal treatment station 38 is advantageously a through-air bonding oven as illustrated in Figure 1. As the consolidated composite web 46 is conveyed on a porous conveyor 50 through the oven, hot gases, typically air, are forced upwardly, downwardly or in both directions, through the composite web. The temperature and dwell time of the consolidated composite web 48 in the oven are adjusted so that the fibers of the meltblown layer 22 are thermally fused to each other. Advantageously, thermal fusion is sufficient that the fused meltblown layer becomes primarily non-fibrous. Thus the layer can be a film-fiber like or a primarily film-like structure. Advantageously, the conditions of temperature and dwell time are insufficient to effect any substantial thermal fusion or bonding of the fibers in fibrous layers 12 and 36 to each other which can result in a stiff and boardy fabric.

The use of through-air bonding oven is particularly advantageous because the fabric is not crushed as it is heated and because heated air is directed to the inside of the fabric. Thus excessive heating of the fabric surface, as when heated calendars or radiant heaters are used, is avoided. As a result, the fabric surface is not substantially stiffened or roughened. In addition, a crushed and boardy fabric texture is avoided.

Various through air bonding ovens are known in the art and are useful herein. One such oven is commercially available from Thermo Electron, Inc. During passage through the oven, the laminate can be supported and/or covered by various porous screens and/or similar members to promote fabric integrity within the moving air currents in the oven.

Although a thermal fusion station in the form of a through air bonding oven is illustrated in Figure 1 and is preferred in the invention, other thermal treating stations such as microwave frequency specific RF or other RF treatment zones which are capable of heating the fabric interior without excessive surface heating and without excessive crushing of the fabric can be substituted for the through air bonding oven of Figure 1. Such conventional heating stations are known to those skilled in the art and are capable of effecting substantial thermal fusion of the meltblown fibers substantially throughout the meltblown web portion of the laminate.

The resultant composite web 52 having a thermally fused bonding layer within the interior of the web exits the thermal treatment zone 48 and is wound up by conventional means on roll 54.

The method illustrated in Figure 1 is susceptible to numerous preferred variations. For example, although the schematic illustration of Figure 1 shows carded webs being formed directly during the in-line process, it will be apparent that the carded webs can be preformed and supplied as rolls of preformed webs. Similarly, although the meltblown web 22 is shown as being formed directly on the carded web 12, meltblown webs can be and preferably are preformed onto a forming screen and such preformed web can be passed directly onto a carded web or can be passed through heating rolls for further consolidation and thereafter passed on to a carded web or can be stored in roll form and fed from a preformed roll onto the carded layer 12. The various webs can also be subjected to prestretching or minimal thermal bonding treatments. Similarly, the three-layer web 38 can be formed and stored prior to hydroentanglement at hydroentangling station 40 and the consolidated hydroentangled web 46 can be stored, dried or otherwise treated prior to passage into and through the thermal treatment zone 48.

Although the method illustrated in Figure 1 employs a meltblown web sandwiched between two carded webs, it will be apparent that different numbers and arrangements of webs can be employed in the invention. Thus, a meltblown web can be employed in combination with a single carded web by forming a meltblown web directly onto a forming screen and by then depositing a performed or in-line formed carded web onto the meltblown. Following hydroentanglement and thermal fusion, the thermally fused bonding layer will be disposed substantially below one surface of the composite nonwoven fabric. Similarly, several meltblown layers can be employed in the invention and/or greater numbers of other fibrous webs can be used.

Nonwoven webs other than carded webs are also advantageously employed in the nonwoven fabrics of the invention. Nonwoven staple webs can be formed by air laying, garnetting, wet laying and similar processes known in the art. In one preferred embodiment of the invention, one or more spunbonded webs can be included within the composite nonwoven fabric. Advantageously, the spunbonded web or webs can be arranged in contact with one or both sides of the meltblown web prior to the thermal fusion treatment.

Thus, for example, a composite fabric can be formed according to the invention by hydroentangling and thermally treating a spunbonded web/meltblown web/carded web laminate; a carded web/spunbonded web/meltblown web/carded web laminate; a spunbonded web/meltblown web/spunbonded web/carded web laminate; a carded web/spunbonded web/meltblown web/spunbonded web/carded web laminate; laminates constructed as per the above but substituting a wet laid staple or staple and wood pulp web for the carded web; or the like.

When the meltblown web 22 is an elastomeric meltblown web, the elastic meltblown web can advantageously be stretched prior to lamination and hydroentanglement with the other layers. The elastic meltblown web can be stretched in either the machine direction (MD) or the in the cross-machine direction (CD) or in both directions, layered with one or more webs of nonelastic fibers, as described above, and then hydroentangled while in the stretched condition. In passing from the manufacturing apparatus to the point of layering with the nonelastic web, the meltblown elastic web can be stretched in one or both the machine direction and cross-machine direction orientations by the use of tenter frames or spreading rolls. Stretching of a meltblown web and hydroentangling of the stretched meltblown web with a fibrous web is described in U.S. 4,775,579 to Hagy, et al. which is incorporated herein by reference in its entirety. Advantageously, when the elastic meltblown web is stretched during hydroentanglement, the resulting hydroentangled web is relaxed prior to the thermal bonding treatment. Such a stretching step can be used to impart various desirable properties to the final fabric including stretch bias or differential elasticity and/or to control the available fabric elasticity range.

When an elastomeric melt blown web is used to provide the thermally fused bonding layer in the composite fabrics of the invention, the elastic properties of the composite fabric can be enhanced according to another aspect of the invention, by a post-formation stretch conditioning treatment. The post-formation conditioning treatment is conducted on the composite bonded fabric following cooling of the composite bonded fabric. Stretching of the fabric is conducted using tenter frames, S-roll drawing, bow rolling, creping treatment, and/or stretching rolls to condition the fabric in the CD and/or MD direction respectively.

Advantageously the fabric is stretched to an extent close to the elastic limit of the fabric although lesser amounts of stretching are also beneficial. The stretch conditioning treatment ruptures a portion of the elastomeric bonds within the fabric and imparts improved elastic properties to the fabric including an improved stretch recovery. Additionally the loss of fabric strength or tension with repetitive stretch cycling can be minimized by the post-formation stretch conditioning treatment.

Figures 2-7 illustrate photomicrographs of preferred web structures of the invention. The web shown in Figures 2-5 is formed from the combination of a meltblown web sandwiched between sheath/core bicomponent fibrous carded webs prior to hydroentanglement. Figure 2 is a top view of the web from which it can be seen that the carded staple fibers are substantially free of bonding, either to each other or to the thermal bonding layer. The cross section of the composite fabric can be seen in Figure 3. The thermally fused meltblown layer is seen to be maintained in a substantially discrete region of the fabric cross section and beneath both top and bottom surfaces of the fabric.

In Figure 4 the fused meltblown fibers are shown in a photomicrograph taken from the top of the fabric while focusing on the interior thereof. It can be seen that the thermally treated meltblown fibers have lost a significant portion of their fibrous nature and are bonded to each other and to staple fibers in the web. In Figure 5 the thermal fusion of the meltblown layer is even more clearly illustrated. It will be also seen that some fibers are coaxially formed of a central core and an outer sheath. These coaxially formed fibers are bicomponent polyester/polyethylene staple fibers wherein the polyethylene constitutes the sheath and the polyester constitutes the core of the fibers. It will be seen that the bicomponent staple fibers pass into and through the fused layer of meltblown fibers and at least a portion of the staple fibers are bonded to the meltblown thermally fused layer.

Figures 6 and 7 illustrate a similar composite nonwoven web of the invention formed from a carded web/meltblown web/carded web structure. In the case of the fabrics shown in Figures 6 and 7, it will be apparent that the meltblown central layer has been thermally treated sufficiently for substantially complete fusion of the meltblown layer. Thus, the central bonding layer exists primarily as a film-like structure and substantially all of the fibrous structure has been destroyed. As will be apparent by comparison of the central layers of the fabrics shown in Figures 2-5 with the fabrics of Figures 6-7, the degree of fiber degradation or fusion can be widely varied from structures having a primarily film/fiber nature on the one hand, to structures having a primarily film-like nature on the other hand.

The thermoplastic polymer used to form the meltblown layer, prior to thermal treatment, can be any of various thermoplastic fiber forming materials known to the skilled artisan. Such materials include polyolefins such as polypropylene and polyethylene; polyesters such as poly(ethylene terephthalate); polyamides such as poly(hexamethylene adipamide) and poly(caproamide); polyacrylates such as poly(methylmethacrylate) and poly(ethylmethacrylate); polystyrene, thermoplastic elastomers, and

blends of these and other known fiber forming thermoplastic materials.

The thermoplastic elastomers include the diblock and triblock copolymers based on polystyrene (PS) and fully hydrogenated poly(ethylene-cobutylene) (EB) and have the formula: $(PS)_a$-$(EB)_b$ or $(PS)_a$-$(EB)_b$-$(PS)_c$ wherein a, b, and c are integers. Preferred elastomers of this type include the KRATON-G polymers sold by Shell Chemical Company. Other elastomeric thermoplastic polymers include the polyurethane elastomeric materials such as ESTANE sold by BF Goodrich Company; polyester elastomers such as HYTREL sold by E.I. DuPont De Nemours Company; polyetherester elastomeric materials such as ARNITEL sold by Akzo plastics; and polyetheramide elastomeric materials such as PEBAX sold by ATO Chemie Company.

Blends of the above thermoplastic polymers are also advantageously used including blends of nonelastic polymers such as polypropylene/polyethylene blends and blends of elastomeric polymers, and blends of elastomeric and non-elastomeric polymers such as kraton/polyolefin blends. In a particularly perferred embodiment of the invention, an adhesive polymer is included as a minor component in the blend, i.e. from about 5% by weight up to about 50% by weight, preferably from about 10 to about 40% by weight. Adhesive thermoplastic materials are known in the art and include poly(ethylene-vinyl acetate) polymers having an ethylene content of up to about 50% by weight, preferably between about 15 and about 30% by weight, and copolymers of ethylene and acrylic acid or esters thereof such as methylacrlyate or ethyl acrylate wherein the acrylic acid or ester component ranges from about 5 to about 50% by weight, preferably from about 15 to 30% by weight.

Use of an adhesive thermoplastic polymer as a component of the meltblown fibers used to prepare fabrics of the invention is particularly advantageous for a number of reasons. Typically, the adhesive thermoplastic materials have a relatively low melting point and thus lower the melting and/or softening point of the meltblown fibers or parts thereof made from the blend. In addition, the adhesive thermoplastic polymers improve the bonding of the thermally fused bonding layer (resulting from heat treatment of the meltblown layer) to the other fibers in the composite fabrics of the invention.

One particularly preferred thermoplastic elastomer/adhesive thermoplastic polymer blend used to make the meltblown layer is a melt blend of between about 50 and about 80 weight percent of a diblock or triblock copolymer of the formula $(PS)_a$-$(EB)_b$ or $(PS)_a$-$(EB)_b$-$(PS)_c$ wherein a, b, and c are integers, together with 20-50 weight percent poly(ethylene/acrylic acid) or poly(ethylene/alkyl acrylate) copolymer, wherein "alkyl" represents methyl, ethyl, propyl, butyl or the like, and wherein the acrylic acid or acrylate ester constitutes from about 5 to about 50 weight percent, preferably 15 to about 30 weight percent of the copolymer. The preferred elastomeric component is a KRATON-G type triblock copolymer as described previously. These particular blends can be meltblown at higher throughputs or at lower dye pressures as compared to blends of the same elastomer with similar melt viscosity reducing materials. In addition, when the meltblown web is preformed and stored in a roll from, blocking of the roll is minimized. Moreover, these elastomeric blends adhere well to staple fibers, particularly staple fibers having a polyolefin surface.

Staple fibers used in the fibrous layer of the nonwoven fabrics of the invention can be any of the various synthetic and/or natural fibers known to those skilled in the art. Preferred synthetic staple fibers include polyester, polyolefin such as polypropylene and polyethylene, nylon, acrylic, modacrylic, rayon, cellulose acetate, biodegradable synthetics such a biodegradable polyester, aramide, fluorocarbon, polyphenylene sulfide staple fibers and the like. Preferred natural fibers include wool, cotton, wood pulp fibers and the like. Blends of such fibers can also be used. In addition, all or a portion of the staple fibers can be glass, carbon fibers or the like.

In one advantageous embodiment of the invention, the staple fibers employed can be bicomponent or multi-component fibers such as sheath/core, side by side, sectorized, or similar bicomponent fibers wherein at least one component of the fiber is polyethylene. The bicomponent fibers can provide improved aesthetics such as hand and softness based on the surface component of the bicomponent fibers, while providing improved strength, tear resistance and the like due to the stronger core component of the fiber. Preferred bicomponent fibers include polyolefin/polyolefin and polyolefin/polyester sheath/core fibers such as a polyethylene/polyethylene terephthalate and a polyethylene/polypropylene sheath core fiber.

Fabrics of the invention can have numerous benefits and advantages as compared to similar hydroentangled fabrics which have not been thermally bonded. Such benefits and advantages can include an increase in peak tensile strength; improvement in tensile strength at full elongation; improvement in percent recovery (in the case of stretch or elastic fabrics); and retention of a high peak elongation (in the case of elastic fabrics). In addition, the fiber tie-down is substantially improved as compared to hydroentangled fibers which have a tendency to disentangle under high load. Despite the thermal bonding throughout the length and width of the fabric, the composite nonwoven fabric is very textile-like, breathable and has a pleasing hand.

The invention including the composite fabrics and methods of forming the same, is inherently flexible and is capable of providing elastic and non-elastic fabrics having a wide variety of textures, wetability

properties, softness properties and strength properties. The selection of specific components combined with the control of processing conditions thus provides for the production of elastic and non-elastic nonwoven fabrics having a wide range of properties.

The following examples serve to illustrate the invention but are not intended to be limitations thereon.

EXAMPLE 1

Two webs of elastic meltblown fibers made from 100 percent Kraton G-1657 and each weighing 60 grams per square yard were plied together and then placed on a foraminous screen of polyester filaments having 13 filaments in the machine direction and 20 filaments in the cross direction. A web of polyester/polyethylene bicomponent staple fibers weighing 18 grams per square yard was placed on top of the meltblown webs. The staple fibers used in this web were BASF 1050 3.0 denier and 1.5 inches in length. The fibers from these webs were hydroentangled with one another using a single manifold with a single row of 0.005 inch diameter orifices spaced 40 per inch along a 12 inch strip. In this example, the layered webs were passed beneath the water jet manifold ten times at a speed of 240 feet per minute. The first two passes were at a manifold water pressure of 400 psi. the next four passes are at a pressure of 800 psi. The last four passes were at a pressure of 1,600 psi.

The hydroentangled sample was then turned over on the foraminous screen and a second web of BASF 1050 bicomponent staple fibers weighing 18 grams per square yard was placed on top of the sample. In this configuration the webs were further entangled by passing them beneath the water jet manifold ten times at a speed of 240 feet per minute. The first two passes were at a water pressure of 400 psi. The next four passes were at a manifold pressure of 800 psi. The last four passes were at a pressure of 1,800 psi.

After drying at room temperature, the sample was placed in a hot air circulating oven for 20 seconds at a temperature of 148°C. The resulting fabric had a smooth surface with a very low linting propensity. Its machine direction tensile strength was 720 gm/in and its breaking elongation was 530 percent. The fabric could be stretched up to 235 percent in the machine direction and then relaxed under zero tension, at which time it retracted to 110 percent of its original length.

EXAMPLE 2

This example is similar to Example 1, except that the elastic meltblown webs were stretched 100 percent of their length in the machine direction before the first staple fiber web was placed on top of them. After the first ten hydroentanglement passes, the sample was removed from-the foraminous screen, relaxed, turned over, stretched 100 percent in the machine direction, and placed again on the screen. A second staple fiber web was placed on top of the sample and this configuration was subjected to a set of 10 hydroentanglement passes, exactly the same as those in Example 1.

The sample was removed from the screen, released and dried at room temperature. It was then placed in a hot air circulating oven for 20 seconds at a temperature of 148°C. The resulting fabric had a smooth surface was a very low linting propensity.

It was considerably stronger than the sample in Example 1. Its machine direction tensile strength was 3,636 grams per inch and its breaking elongation 242 percent. The sample could be stretched up to 84 percent in the machine direction and then released under zero tension, at which time it retracted to 110 percent of its original length.

The invention has been described in considerable detail with reference to its preferred embodiments. However, it will be apparent that numerous variations and modifications can be made without departure from the spirit and-scope of the invention as described in the foregoing detailed specification and defined in the appended claims.

Claims

1. A composite nonwoven fabric, characterized by:
   a fibrous web (12), and
   a bonding layer (22) of thermoplastic material disposed beneath at least one surface of the fibrous web (12) in a substantially discrete portion of the cross-sectional of the fibrous web and comprising a thermally fused thermoplastic web derived from a layer of meltblown thermoplastic fibers.

2. The composite nonwoven fabric according to claim 1, characterized in that said fibrous web (12) comprises staple fibers.

3. The composite nonwoven fabric according to claim 2, characterized in that at least a portion of said staple fibers are bicomponent fibers.

4. The composite nonwoven fabric according to any of the previous claims, characterized in that it comprises additionally at least one spunbonded nonwoven layer (36) intimately hydroentangled with said fibrous web (12).

5. The composite nonwoven fabric according to any of the previous claims, characterized in that said meltblown thermoplastic fibers comprise an adhesive polymer.

6. The composite nonwoven fabric according to any of the previous claims, characterized in that said bonding layer (22) of thermoplastic material is a substantially film-like non-fibrous structure extending throughout the width and length of the fabric.

7. A composite elastic nonwoven fabric, characterized by :

a fibrous web (12), and

a layer (22) of elastomeric material disposed beneath at least one surface of the fibrous web in a substantially discrete portion of the cross-section of the fibrous web and comprising a thermally fused thermoplastic web derived from a layer of elastomeric meltblown thermoplastic fibers.

8. The composite elastomeric nonwoven fabric according to claim 7, characterized in that said fibrous web comprises staple fibers.

9. The composite elastomeric nonwoven fabric according to claim 8, characterized in that at least a portion of said staple fibers are bicomponent staple fibers.

10. The composite elastic nonwoven fabric according to any of claims 7-9, characterized in that it additionally comprises at least one spunbonded web (36) intimately hydroentangled with said fibrous web.

11. The composite elastic nonwoven fabric according to any of claims 7-10, characterized in that said elastomeric meltblown thermoplastic fibers comprise an adhesive polymer.

12. The composite elastic nonwoven fabric according to any of claims 7-11, characterized in that said layer (22) of elastomeric material is a substantially film-like non-fibrous structure extending throughout the width and length of the fabric.

13. The composite elastic nonwoven fabric according to any of claims 7-11, characterized in that said layer of elastomeric material (22) is a film-fiber structure extending throughout the width and length of the fabric.

14. A composite nonwoven fabric, characterized by :

a fibrous web (12) of intimately entangled fibers,

a bonding layer (22) of thermoplastic material disposed in a substantially discrete portion of the cross-section of said fibrous web between the top and bottom surfaces thereof and comprising a thermally fused thermoplastic web derived from a layer of meltblown thermoplastic fibers, and

in that at least a portion of the fibers of said fibrous web extend through said bonding layer so that said bonding layer strengthens said fibrous web and anchors said intimately entangled fibers therein.

15. The composite nonwoven fabric according to claim 14, characterized in that said fibrous web (12) of intimately hydroentangled fibers comprises at least two staple fibrous web intimately hydroentangled with each other.

16. The composite nonwoven fabric according to claim 14, characterized in that said fibrous web (12) of intimately entangled fibers comprises at least one spunbonded web and at least one carded web intimately hydroentangled together.

17. The composite nonwoven fabric according to claim 14, characterized in that said fibrous web (12) of intimately entangled fibers comprises natural fibers.

18. The composite nonwoven fabric according to any of claims 14-17, characterized in that said fibrous web (12) of intimately entangled fibers comprises wood pulp.

19. The composite nonwoven fabric according to any of claims 14-18, characterized in that said fibrous web (12) of intimately entangled fibers comprises bicomponent staple fibers.

20. The composite nonwoven fabric according to claims 14-19, characterized in that said meltblown thermoplastic fibers are formed of a thermoplastic polymer comprising an adhesive polymer.

21. A composite elastic nonwoven fabric, characterized by :

a fibrous web (12, 36) of intimately entangled fibers,

a layer (22) of elastomeric material disposed in a substantially discrete portion of the cross-section of said fibrous web between the top and bottom surfaces thereof and comprising a thermally fused thermoplastic web derived from a layer of elastomeric meltblown thermoplastic fibers, and

in that at least a portion of said fibers of said fibrous web extend through said layer of elastomeric material so that the layer of elastomeric material imparts strength and elasticity to said fibrous web and anchors fibers of said fibrous web therein.

22. The composite elastic nonwoven fabric according to claim 21, characterized in that said fibrous web (12, 36) of intimately entangled fibers is derived from at least two carded webs disposed on opposite sides of said layer of elastomeric material and intimately hydroentangled together.

23. The composite nonwoven elastic fabric according to claim 21, characterized in that said fibrous web (12, 36) of intimately entangled fibers is derived from at least one carded web and at least one spunbonded web disposed on opposite sides of said layer of elastomeric material and intimately hydroentangled together.

24. The composite elastic nonwoven fabric according to claim 21, characterized in that fibrous (12,36) web of intimately entangled fibers comprises staple fibers.

25. The composite elastic nonwoven fabric according to any of claims 21-24, characterized in that said fibrous web (12, 36) of intimately entangled fibers comprises wood pulp.

26. The composite elastic nonwoven fabric according to any of claims 21-25, characterized in that said fibrous web (12, 36) of intimately entangled fibers comprises bicomponent staple fibers.

27. The composite elastic nonwoven fabric according to any of claims 21-26, characterized in that said meltblown thermoplastic fibers are formed of a polymer blend comprising an elastomeric thermoplastic polymer and a thermoplastic non-elastomeric polymer.

28. A composite nonwoven fabric characterized by :

a fibrous web (12, 36) of intimately entangled fibers,

a layer (22) of elastomeric material disposed in a substantially discrete portion of the cross-section of said fibrous web between the top and bottom surfaces thereof and comprising a thermally fused thermoplastic web derived from a layer of elastomeric meltblown thermoplastic fibers,

in that said fibrous web includes a top portion above said layer of elastomeric material and a lower portion below said layer of elastomeric material, each of said top portion and said lower portion of said fibrous web comprising staple fibers and being substantially devoid of fiber bonding,

in that said elastomeric layer includes a plurality of physically ruptured segments resulting from stretching of said elastomeric layer, and

in that at least a portion of said fibers of said fibrous web extend through said layer of elastomeric material.

29. The composite nonwoven fabric according to claim 28, characterized by an additional spunbonded web intimately entangled into said fibrous web.

30. The composite nonwoven fabric according to any of claims 28-29, characterized in that said fibrous web comprises wood pulp.

31. A process for the manufacture of composite nonwoven fabric, characterized in that it comprises the steps of :

forming a layered web including a first fibrous nonwoven layer and a layer of melt blown thermoplastic fibers,

intimately hydroentangling the layered web sufficiently to force fibers of the first fibrous layer into the layer of meltblown thermoplastic fibers to form a hydroentangled laminate, and

subjecting the resultant hydroentangled laminate to a bonding treatment for thermal fusion of the meltblown fibers sufficiently that the meltblown fibers are thermally fused substantially throughout the width and length of the meltblown layer.

32. The process according to claim 31, characterized in that said bonding treatment for thermal fusion of the meltblown fibers comprises conveying said hydroentangled laminate through a bonding oven while passing hot gases through said hydroentangled laminate.

33. The process according to any claims 31-32, characterized in that said layered web comprises a second fibrous layer and in that said layer of meltblown thermoplastic fibers is sandwiched between said first and said second fibrous layers.

34. The process according to any claims 31-33, characterized in that said layer of meltblown thermoplastic fibers is a layer of meltblown elastomeric thermoplastic fibers.

35. The process according to any claims 31-34, characterized by the additional step following said bonding treatment step of stretching the bonded hydroentangled laminate resulting from said bonding treatment sufficiently to improve the elastic properties thereof.

36. A process for the manufacture of a composite nonwoven fabric, characterized by the steps of :

forming a layered web including a first fibrous nonwoven layer, a second fibrous nonwov-

en layer and a layer of melt blown thermoplastic fibers sandwiched between said first and second fibrous layers,

intimately hydroentangling the layered web sufficiently to force fibers of each of the first and the second fibrous layers through the layer of meltblown thermoplastic fibers to form a hydroentangled laminate, and

subjecting the resultant hydroentangled laminate to a bonding treatment for thermal fusion of the meltblown fibers sufficiently that the meltblown fibers are thermally fused substantially throughout the width and length of the meltblown layer.

37. The process according to claim 36, characterized in that said bonding treatment for thermal fusion of the meltblown fibers comprises conveying said hydroentangled laminate through a bonding oven while passing hot gases through said hydroentangled laminate.

38. The process according to any claims 36-37, characterized in that said first fibrous layer is a staple fiber web.

39. The process according to claim 38, characterized in that said second fibrous layer is a staple fiber web.

40. The process according to any of claims 36-39, characterized in that said layer of meltblown thermoplastic fibers is a layer of meltblown elastomeric thermoplastic fibers.

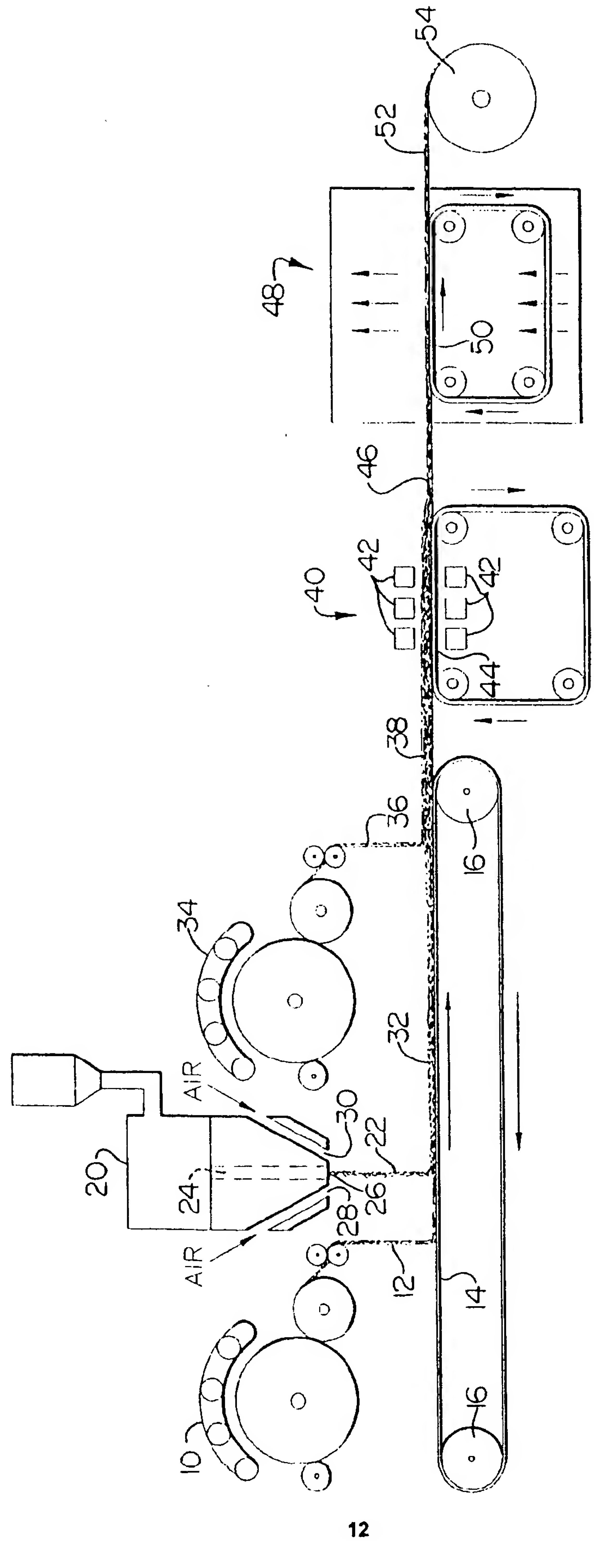
10
12
14
16
16
20
22
24
26
28
30
32
34
36
38
40
42
42
44
46
48
50
52
54
AIR
AIR

FIG. 1

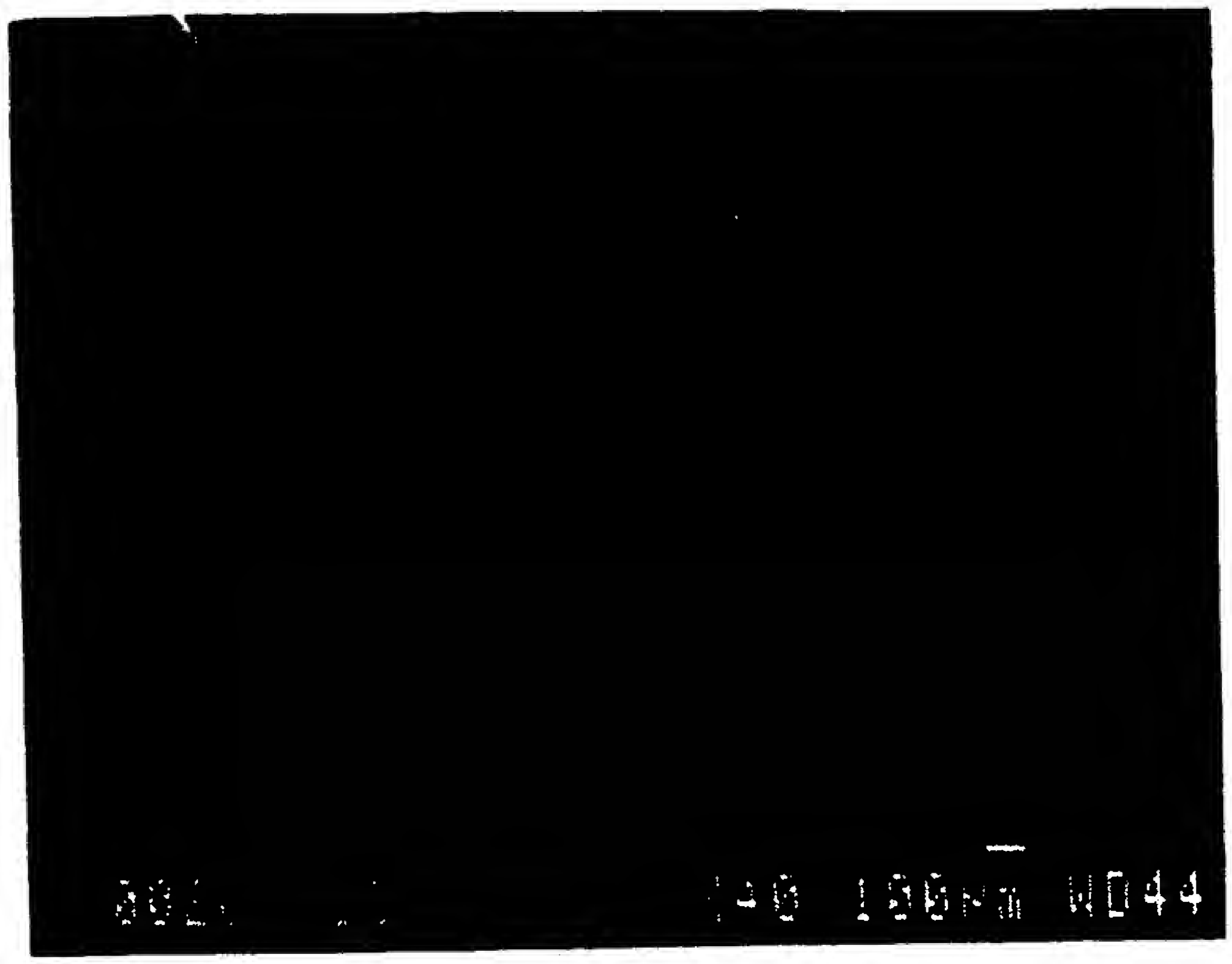

FIG. 2

FIG. 3

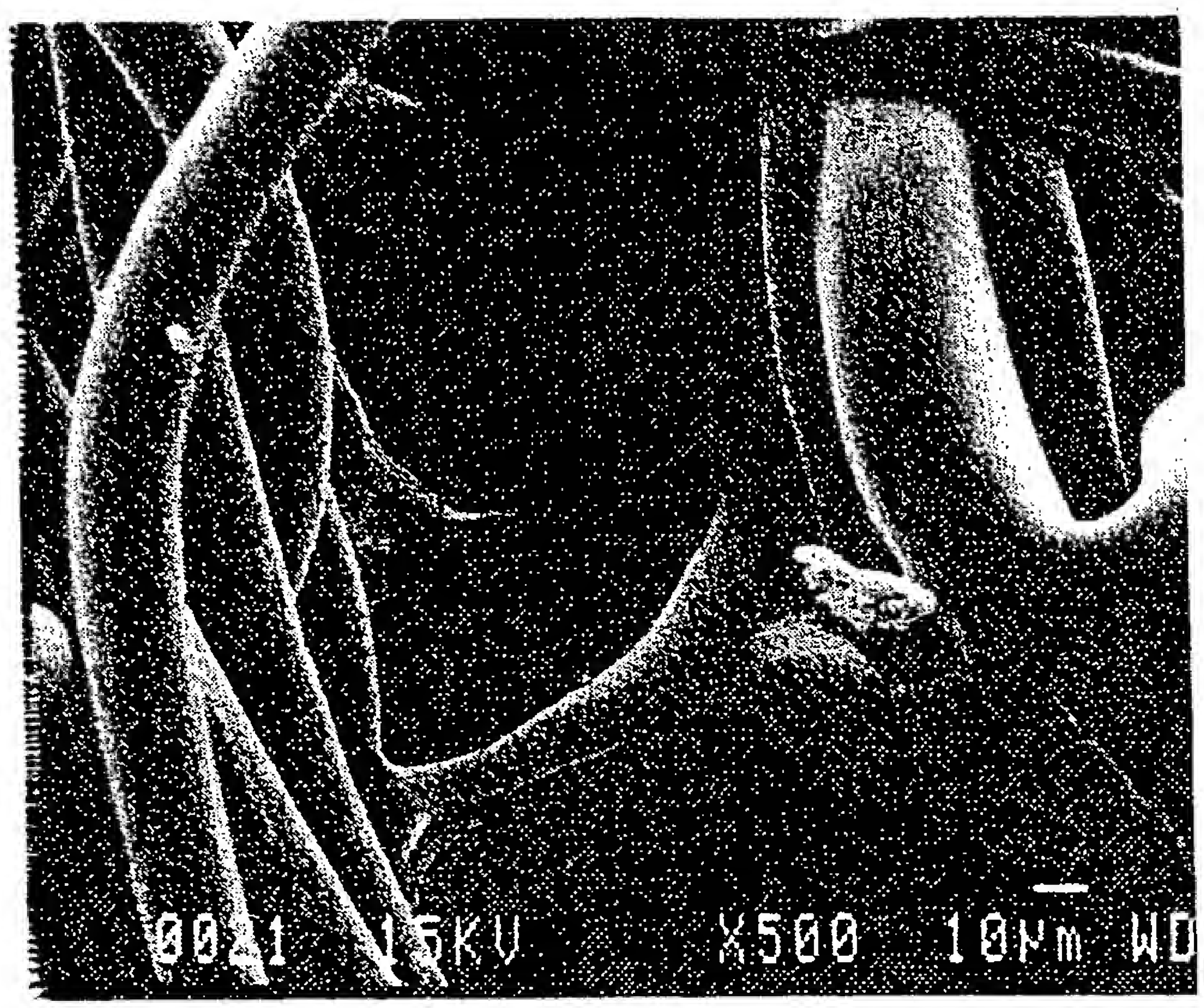

FIG. 4

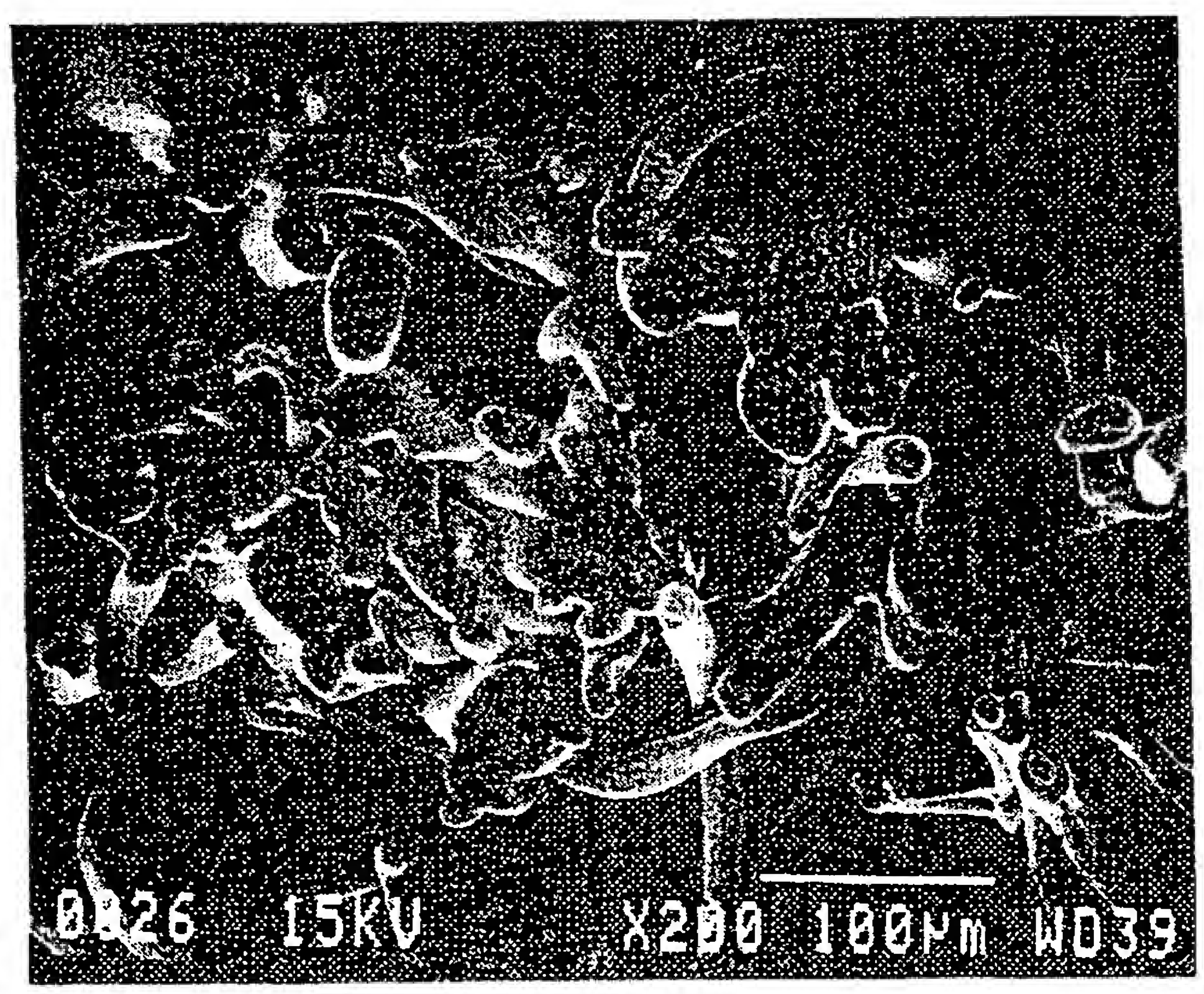

FIG. 5

FIG. 6

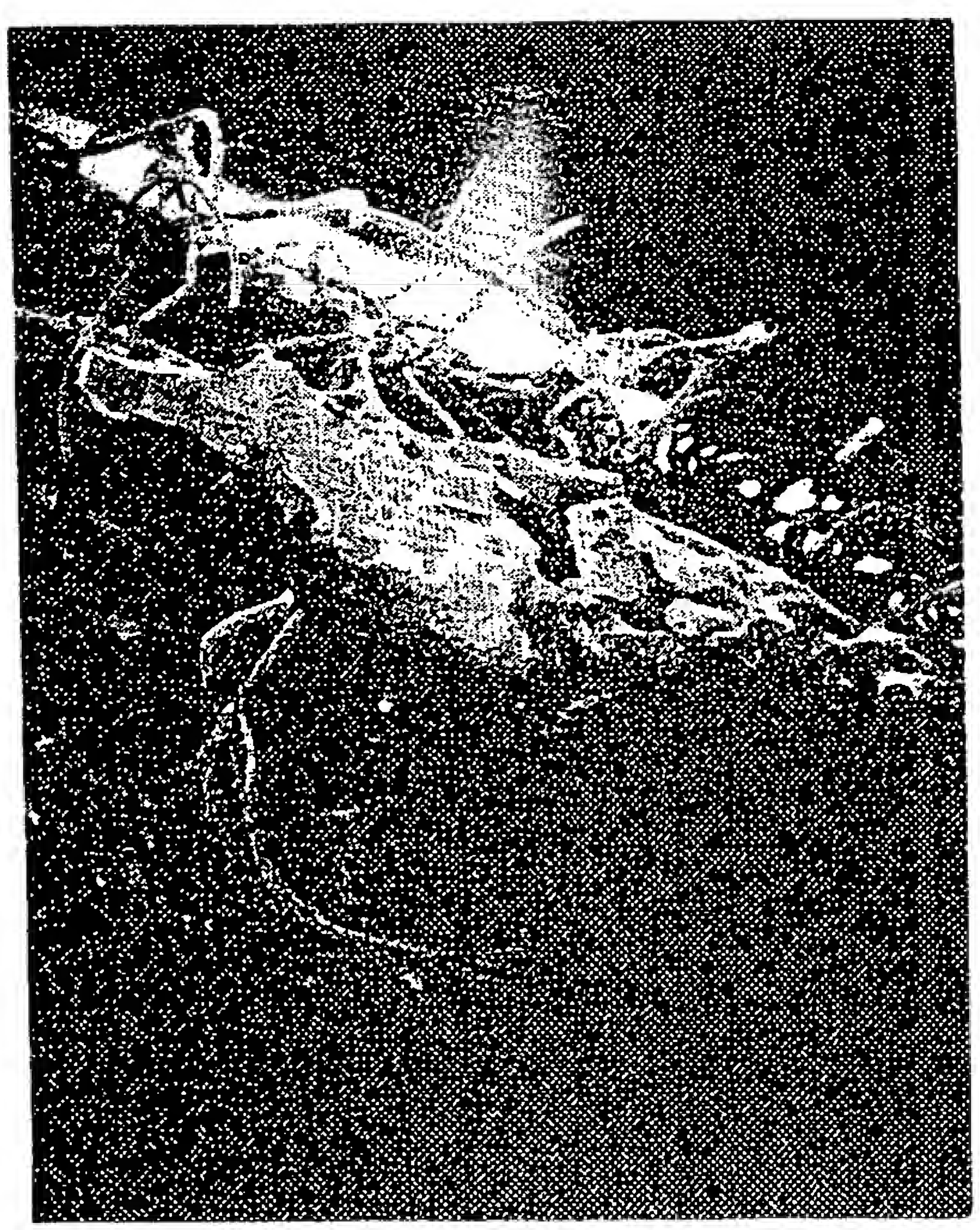

FIG. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 92 40 2646
Page 1

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	US-A-4 939 016 (RADWANSKI ET AL.)	1,2,4,5, 7,8,10, 11,14, 15,17, 18, 20-22,24 25,27, 30,31, 33-36, 38-40	D04H1/54 D04H1/56 D04H13/00
A	* column 3, line 36 - column 13, line 11 *	16,23, 28,29, 32,37	

X	EP-A-0 418 493 (FIBERWEB NORTH AMERICA,INC.)	1-3,5, 14,17, 19,20, 31,33, 36,38,39	
A	* page 4, line 45 - page 8, line 3 *	7-9,11, 22,24, 26,28	TECHNICAL FIELDS SEARCHED (Int. Cl.5)

Y	US-A-4 775 579 (HAGY ET AL.)	1,2,5-8, 11-15, 17,18, 20-22, 24,25, 31,33,34 36,38-40	D04H
A	* whole document *	28,30	

	-/--		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 NOVEMBER 1992	VAN BEURDEN-HOPKINS

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 40 2646
Page 2

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	US-A-4 885 202 (LLOYD ET AL.) * whole document * ---	1,2,5-8, 11-15, 17,18, 20-22, 24,25, 31,33,34 36,38-40	
A	FR-A-2 654 752 (KAYSERSBERG) * page 5, line 28 - page 6, line 3 * -----	32,36,37	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 NOVEMBER 1992	VAN BEURDEN-HOPKINS

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)